Automated CO_2 & CH_4 flux measurements with the eosAC and the LGR Ultra-Portable Greenhouse Gas Analyzer

Introduction

This application note provides simplified setup instructions for interfacing the Eosense eosMX-P multiplexer and eosAC soil flux chambers with the Los Gatos Research Ultra-Portable Greenhouse Gas Analyzer (UGGA) and demonstrates the use of the system to collect CO_2 and CH_4 gas flux measurements at an experimental crop rotation field site.

> **IMPORTANT:** This application note is not a replacement for the full user manual. Users are advised to read the full user manuals for each product before proceeding.

Connecting the UGGA and eosMX-P

Required Components

- LGR UGGA
- eosMX-P
- Tubing (2 x 60 cm lengths PTFE)
- ¼" Ferrule x 2 (SS-403-1, SS-404-1)
- ¼" Swage Nut x 2 (SS-402-1)

The eosMX-P and UGGA are connected by two lengths of tubing (responsible for recirculating the chamber gas) and two USB cables (responsible for data transmission and chamber control). One end of the tubing should be left bare while the other end will require a Swage nut and ferrule. Attach the bare ends of the tubing to the INLET and WASTE ports on the side of the UGGA by pushing the tubing into the quick connect ports until held securely (Figure 1).

Figure 1. Attach the bare ends of the tubing to the INLET and WASTE ports on the UGGA.

Attach the Swaged end of the tubing connected to WASTE on the UGGA to OUTLET on the eosMX-P. Attach the Swaged end of the tubing connected to INLET on the UGGA to INLET on the eosMX-P. Hand tighten the Swage nuts and then turn a further 1 ¼ turns (9/16" or adjustable wrench) to secure.

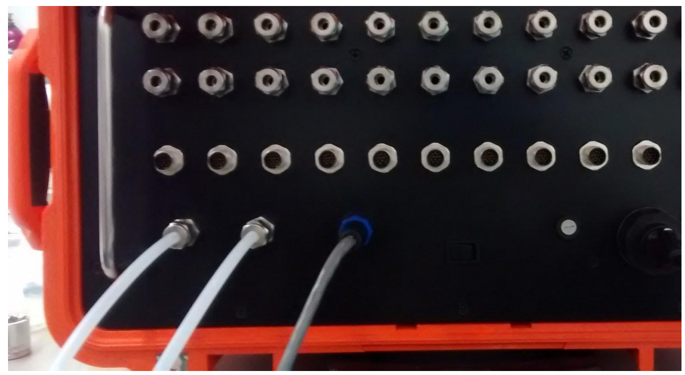


Figure 2. Attach the Swaged ends of the tubing to the eosMX-P, and turn a further 1 ¼ turns to compress the ferrules.

Connect the power and both the CONTROL and DATA USB cables to the eosMX-P and then to the power source and USB ports on the side of the UGGA, respectively (Figure 3).

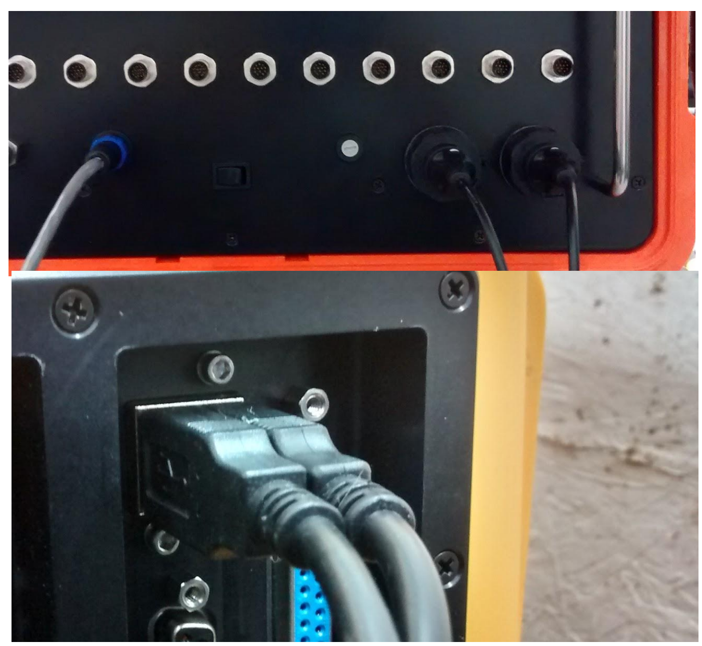


Figure 3. Attach the power and USB connections to the eosMX-P and plug the USB connections into the UGGA USB ports.

Connecting the eosAC's to the eosMX-P

Each eosAC is connected to the eosMX-P multiplexer through two lengths of tubing and one power/data cable. Using the provided eosAC tubing bundle, insert the bare ends of the tubing into the Inlet and Outlet ports on the rear of the eosAC. Attach the Swaged end of the tubing connected to the eosAC Inlet port to Inlet 1 on the front of the eosMX-P. Next, attach the Swaged end of the tubing connected to the eosAC Outlet port to Outlet 1 on the front of the eosMX-P (Figure 4).

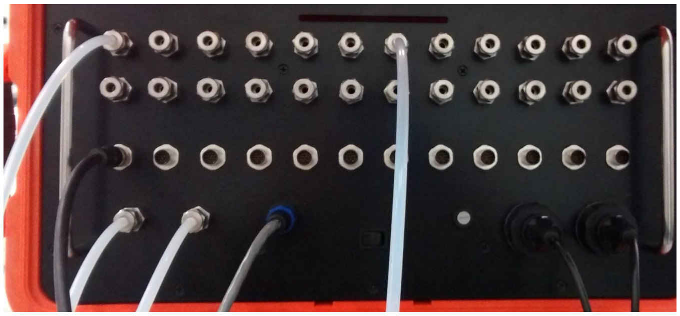


Figure 4. Attach the Swaged ends of the eosAC tubing to the eosMX-P on inlet and outlet port 1 and attach the AC power/data cable to COMM 1.

Attach the power/data cable to the COMM 1 port of the eosMX-P and then to the COMM port (top left) on the back of the eosAC (Figure 5). Repeat this process of connecting the tubing and the communication cable for each eosAC that will be connected to the eosMX-P, ensuring that each new eosAC is connected to matching port numbers (Input 2, Outlet 2, COMM 2, etc).

Figure 5. Attach the end of the INLET and OUTLET tubing to the eosAC and attach the COMM cable to the top left electrical port (labelled COMM).

Scheduling Chamber Measurements

The eosLink-MX software, which runs on the UGGA, serves as the control panel for up to 12 eosAC's and logs chamber peripheral data. Users can customize measurement schedules, incorporating both chambers and calibration standards, which can be run as a single sequence or looped continuously.

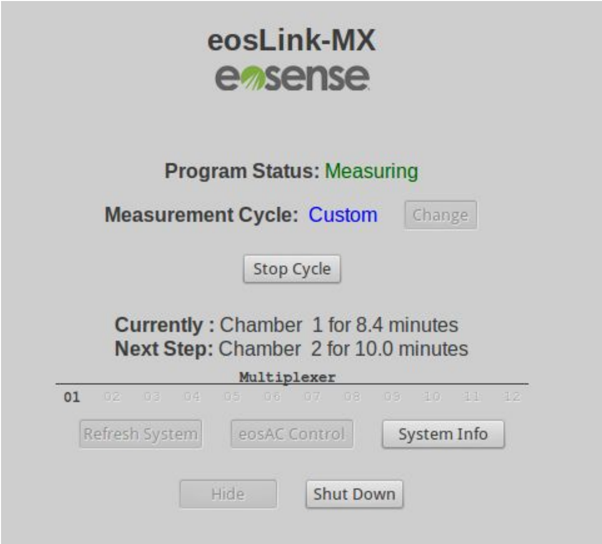


Figure 6. eosLink-MX software showing the main window during an active measurement cycle.

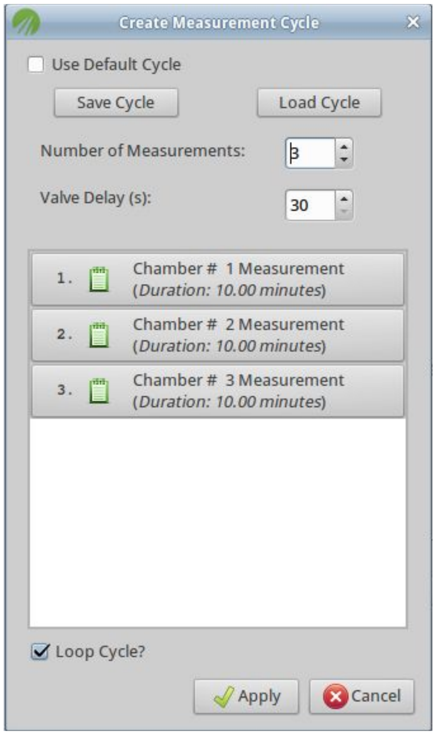
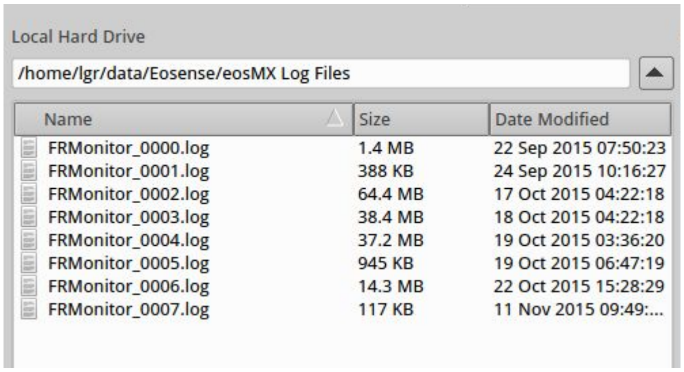


Figure 7. eosLink-MX software showing a custom measurement cycle of repeating, sequential 10 minute chamber closures for each eosAC.

To access eosLink-MX software when connected to the UGGA, switch to the second Desktop (default short-cut: <Ctrl> + <Alt> + <Right Arrow>) and launch the software from the shortcut. After a short warm up period, custom measurement cycles can be created and started.

Data Processing

Once all the measurements have been gathered, transfer the analyzer and eosMX-P log files to your Windows PC through the normal UGGA interface. Collect all relevant analyzer data files (e.g. gga_2015-10-22_f0000.txt) as well as all FRMonitor_NNNN.log files, located in "/home/lgr/data/".

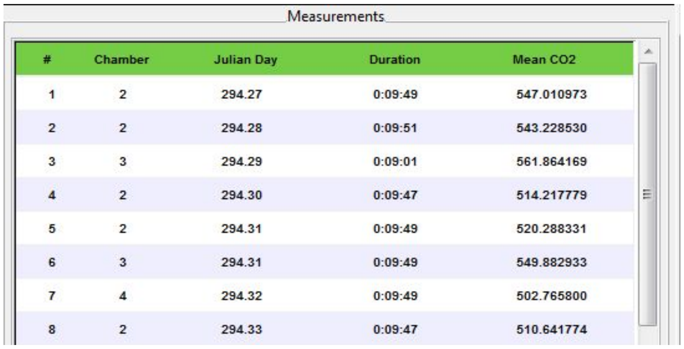


Name	Size	Date Modified
FRMonitor_0000.log	1.4 MB	22 Sep 2015 07:50:23
FRMonitor_0001.log	388 KB	24 Sep 2015 10:16:27
FRMonitor_0002.log	64.4 MB	17 Oct 2015 04:22:18
FRMonitor_0003.log	38.4 MB	18 Oct 2015 04:22:18
FRMonitor_0004.log	37.2 MB	19 Oct 2015 03:36:20
FRMonitor_0005.log	945 KB	19 Oct 2015 06:47:19
FRMonitor_0006.log	14.3 MB	22 Oct 2015 15:28:29
FRMonitor_0007.log	117 KB	11 Nov 2015 09:49:...

Figure 8. UGGA file transfer screen showing eosMX-P log files.

Copy the analyzer files to your PC and the eosMX-P log files to the eosAnalyze-AC software folder. Run the eosAnalyze-AC software, selecting "LGR UGGA" as the analyzer type and "Eosense eosAC (Multiplexed)" as the chamber type. Set the data path as the location where the UGGA analyzer data was copied. Adjust your specific setup parameters (tubing length, collar height, etc) from the Chamber and Analyzer Settings window, then import your measurements by specifying a date range in the Collect Data window.

Once your measurements have been imported, customize the data table (Figure 9) as desired and export your data to a spreadsheet compatible file.



#	Chamber	Julian Day	Duration	Mean CO2
1	2	294.27	0:09:49	547.010973
2	2	294.28	0:09:51	543.228530
3	3	294.29	0:09:01	561.864169
4	2	294.30	0:09:47	514.217779
5	2	294.31	0:09:49	520.288331
6	3	294.31	0:09:49	549.882933
7	4	294.32	0:09:49	502.765800
8	2	294.33	0:09:47	510.641774

Figure 9. eosAnalyze-AC software showing a sample of measurement data for each chamber closure.

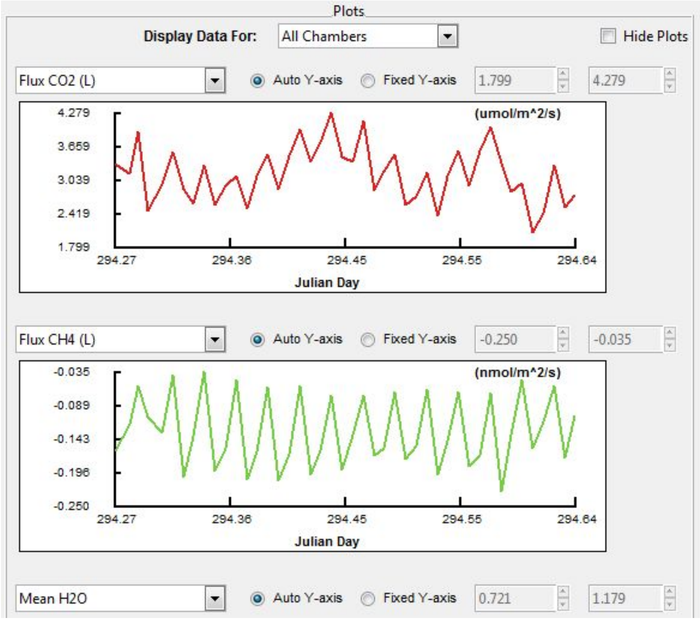


Figure 10. eosAnalyze-AC software showing plots of CO_2 / CH_4 fluxes for each of the three chambers.

Example Deployment

The example images shown throughout this application note were drawn from the deployment of an LGR UGGA with an Eosense eosMX-P multiplexer and three eosAC flux chambers. The deployment was at an experimental crop rotation site in Truro, Nova Scotia that was used for biosolids addition experiments in past years, with each plot receiving a different treatment regime. Each eosAC was deployed on a separate treatment plot and connected to the eosMX-P using 15 m of ⅛" ID teflon (PTFE) tubing.

Figure 11. eosAC deployed on Plot 2 at the field site in Truro, Nova Scotia on October 22, 2015.

On October 22, 2015, the system was configured for a repeated cycle of 10 minute closures over an 8 hour period, collecting a total of 39 flux measurements (13 per chamber). This data is shown in Figures 12 and 13 for CO_2 and CH_4, respectively.

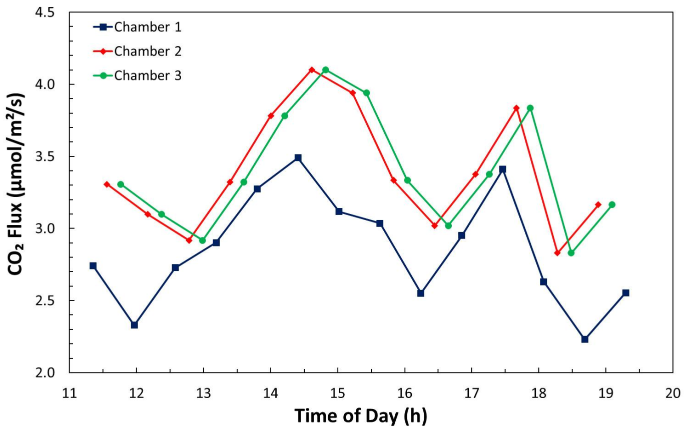


Figure 12. CO_2 flux measurements from each of the three eosACs using a linear fit to the chamber concentration time series. Each chamber shows a similar temporal pattern in CO_2 emissions.

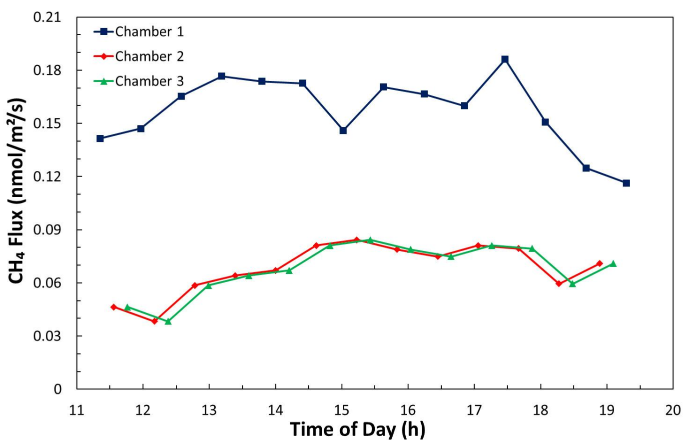


Figure 13. CH_4 uptake measurements from each of the three eosACs using a linear fit. Each chamber shows a similar temporal pattern, with chamber 1 showing significantly higher methane consumption.

All three chambers showed approximately the same response patterns, with CO_2 emissions between 2.2 and 4.1 µmol/m^2/s (peaking in the early afternoon), while CH_4 fluxes showed a consistent but spatially variant uptake between 0.03 and 0.23 nmol/m^2/s. As shown in Figure 12, Chamber 1 had similar but noticeably lower CO_2 emission rate when compared to the other two plots. Interestingly, this chamber also displayed significantly higher CH_4 uptake than the other plots (Figure 13).

Conclusions

Eosense's eosMX-P and eosAC products now offer LGR users an all-in-one solution for measuring multi-species soil gas flux. The eosMX-P provides a ruggedized 12-port recirculating UGGA-compatible multiplexer, and the ability to link up to 12 eosAC soil flux chambers to the UGGA.

During our field experiment, the combined system was successful in measuring a typical diurnal cycle in soil CO_2 efflux (peaking at approximately the same time as peak soil temperature) and was also able to detect small but significant uptake of CH_4. This small, consistent CH_4 uptake has been noted in agricultural systems, however the unique combination of automated chambers and high-resolution gas concentration measurements allow us to detect it with much higher certainty than would be possible with traditional soil flux techniques.

Acknowledgments

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